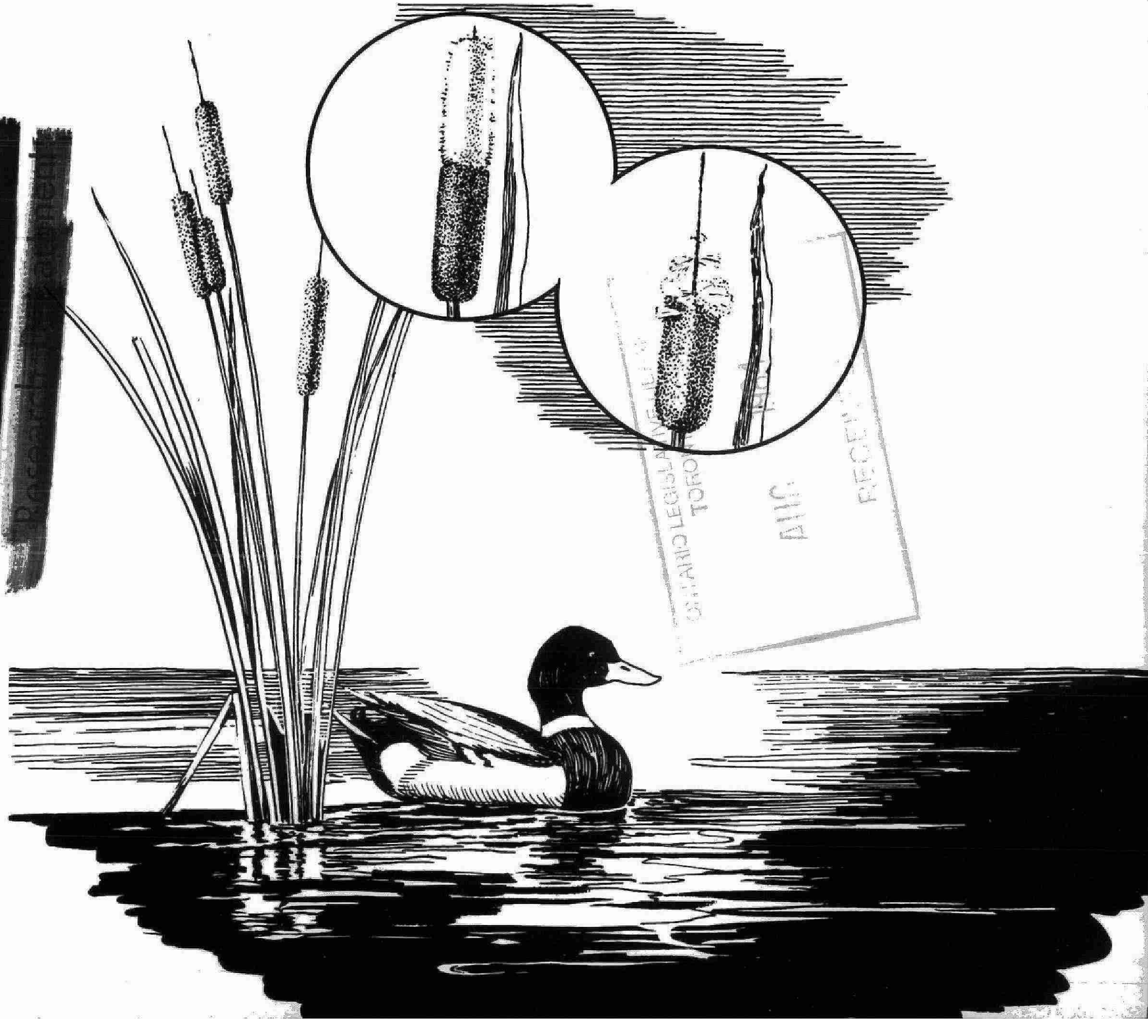
Biological Aspects of Water Management



Water management in Ontario

Ontario
Water Resources
Commission

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Introduction

This publication is designed to provide information on aquatic life and its relationship to water management. Many aspects of the water supply and pollution control responsibilities of the Ontario Water Resources Commission require an understanding of how living things affect our use of the water or reflect the degree to which ideal water quality has been changed by human neglect or misuse.

In addition, a more recent concept relates to the ability of man to modify or improve conditions through the use of environmental or artificial controls such as the selection of design criteria for ponds or reservoirs that will limit the development of nuisance aquatic plants, or the use of approved aquatic herbicides for the same purpose.

The Ontario Water Resources Commission employs biologists and supporting technical staff in its Biology Branch who are responsible for pollution evaluation surveys, investigations of algae problems at water treatment plants, fish bioassay and toxicity tests and evaluations of chemicals and the issuance of permits for aquatic nuisance control measures.

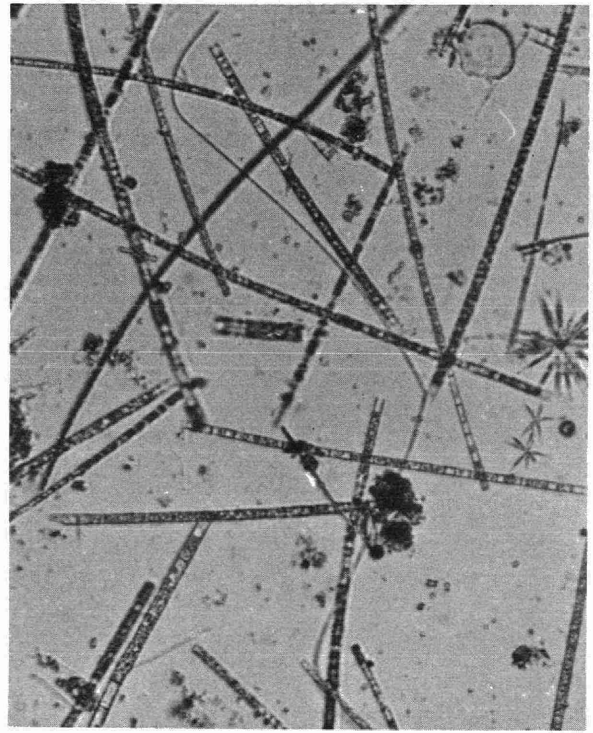
It is hoped that this booklet will familiarize teachers, students and interested citizens with the role of biology in the work of the OWRC and that the list of references provided may be an additional source of information to those who wish to obtain more details on any phase of aquatic biology.

Algae, phytoplankton and water supplies

Algae are plants of simple structure and organization, the most primitive of which are comprised of a single cell. They are considered primitive because each cell is capable of carrying out all life processes, as no specialization has been developed into various tissues such as are found in the higher plants (e.g., leaves, roots, stems, seeds). The algae vary in size from microscopic forms to large seaweeds which may extend several hundred feet in length. In addition to living in the ocean, lakes or rivers, usually down to a depth where light can penetrate, algae can live on damp soil and on the face of glaciers.

The free-floating microscopic algae, collectively called phytoplankton or planktonic algae, are only slightly motile and exist at or near neutral buoyancy. As such, they are subject to lake currents, and considerable variations in phytoplankton conditions may be experienced at any location over short periods of time. In contrast, certain species, collectively called periphyton, are able to attach themselves to various substrates including rocks, branches, vascular aquatic plants, other algal forms and fish. Algal production in a body of water is influenced by sunlight; temperature; size, shape and slope of the lake basin; type of substratum; water movements; dissolved mineral content and other aspects of water quality.

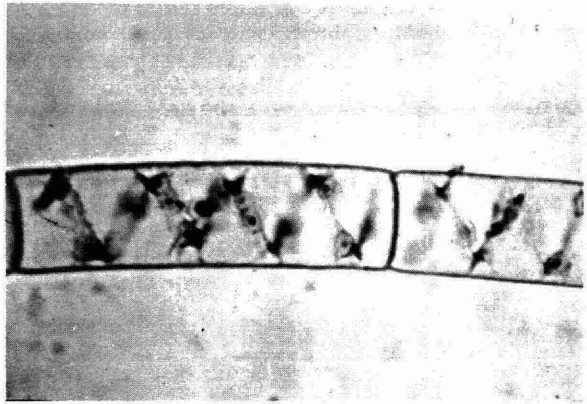
Algae are normal inhabitants of nearly all suface waters. Indeed, the beneficial aspects of algae are often overlooked by individuals who consider algae to be the implacable villains of our lakes and rivers. Phytoplankton



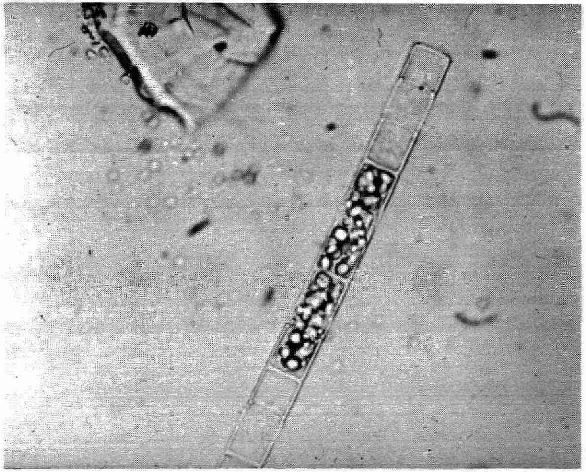
Phytoplanktonic algae

along with somewhat larger planktonic animals (zooplankton) form an important constituent in the aquatic food chain, especially in nourishing the early life stages of fish. Many scientists have suggested that algae may be utilized by man as food, and in certain areas of the world algae form a significant part of the local diet. Man is currently controlling algae to accomplish work. Algae are autotrophic, that is, by their photosynthetic activities they are able to convert carbon dioxide and dissolved minerals into organic compounds (starches, sugars, proteins) and oxygen. The generation of this oxygen may be utilized in the stabilization of waste-waters in oxidation ponds. The provision of oxygen by aquatic plants and algae plays an essential role in the purification of streams, rivers and lakes. Additionally, an oxygen balance is essential for fish life and helps in maintaining a suitable environment for the production of fish food organisms. Because of their relatively simple structure and nutritive requirements, many species of algae are ideally suited for research projects. Some researchers believe that when men start making extended trips into space, the food they will consume will be algae grown in the space capsule.

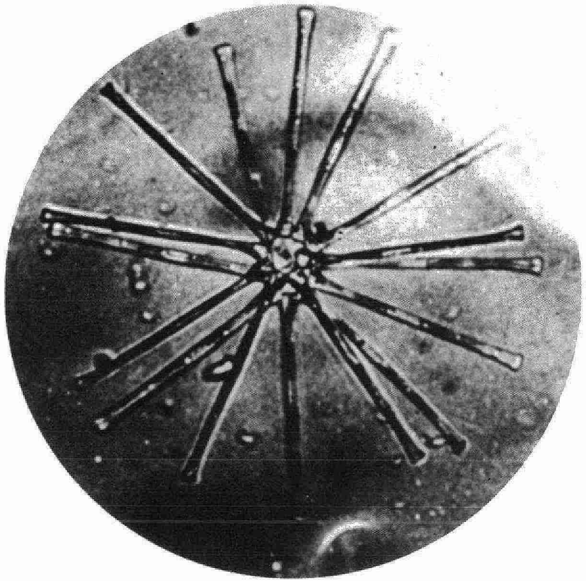
On the other hand, water treatment plant operators often look upon algae as purely a nuisance as they clog filters (thereby reducing filter runs) and impart obnoxious tastes and odours to the water. In all cases, the problems stem from an overabundance, but the numbers required to create the difficulties will vary. A dramatic example of reduction in filter runs occurred in November of 1963 when the diatom *Melosira* temporarily affected nearly all water-works installations between Hamilton and Kingston, and the plant at Scarborough was removed from service for several days. Water in a number of small Northern Ontario lakes (Apsey Lake near Espanola, Clarke Lake near Bancroft, Turner Lake near Cache Bay and Gull Lake near Kirkland Lake), as well as the Great



Starches and sugars are produced in the spiral chloroplasts of the filamentous alga Spirogyra



Melosira—a filter-clogging alga



Asterionella—causes fishy taste and odour

Lakes, has been rendered periodically unpalatable because of the presence of troublesome levels of one or more species of algae.

One of the best methods of providing good quality water for municipal use is to select the best possible source of supply. For this purpose, a Phytoplankton Inventory Program has been established to gain information on types and numbers of algae and to obtain estimates on the productive capacity of selected waters throughout the province. Lakes, rivers or reservoirs, offering potential as a source of municipal supply, are assessed by means of chemical and biological analyses for at least one year prior to the installation of any waterworks facilities. In addition to influencing in-plant design and treatment facilities, this program enables the OWRC to provide aid to municipalities by recommending possible sources for municipal supply without long-term delays.

The scope of the Commission's program related to phytoplankton studies has been expanded to include an Algae Identification and Enumeration Course which is offered annually to water treatment plant operators. In addition to providing information on the biological quality of water at a number of municipalities along the Great Lakes and from various inland waters, this course promotes a better understanding amongst waterworks operators of the significance of algae as they affect water treatment processes, and of the remedial measures that may be implemented to offset algae-caused problems.

Algae and aquatic enrichment

All lakes, including those entirely unaffected by man's activities, are transitory bodies of water and are slowly undergoing ageing processes brought about by run-off from the land which causes physical sedimentation and a gradual increase in dissolved mineral content. The impact of increases in levels of nutrients, including carbon, phosphorous and nitrogen, as well as other mineral salts such as calcium and silica, varies with climatic conditions, the shape and size of the lake basin, thermal conditions in the lake and turbidity and colour (which affect light penetration and hence the depth of the phototrophic zone). These factors interplay with the chemical content of the water to regulate the production of numerous algal species as well as larger attached forms of algae and vascular aquatic vegetation.

Where artificial enrichment through inputs of domestic and industrial wastes, agricultural run-off and seepage from septic tanks occurs, the ageing or eutrophication process is tremendously accelerated. During periods of warm, calm, sunny weather, algae multiply and accumulate in large masses sufficient to form 'water-blooms'. Such 'blooms' impair recreational aesthetic values by reducing the clarity of the water for swimming and other water sports and by accumulating along shorelines where the masses of phytoplankton decompose in an unsightly and odorous manner. Attached algae may break from its substrate in rough weather and be washed ashore to rot. Cottage water intake filters often become clogged with algae, and shallow recreational lakes may become choked with weeds, rendering them unsuitable for boating and swimming. Population structures in all levels of the food chain shift, ultimately resulting in a change from desirable sport fish species to undesirable coarse fish species. Figure 1 illustrates the differences between a nutrient-poor and a nutrient-rich lake.

The increased production in a lake, therefore, reflects the presence of high concentrations of essential plant nutrients in the aquatic environment, just as farm crops

Accumulations of the alga Cladophora along the shoreline of Lake Ontario

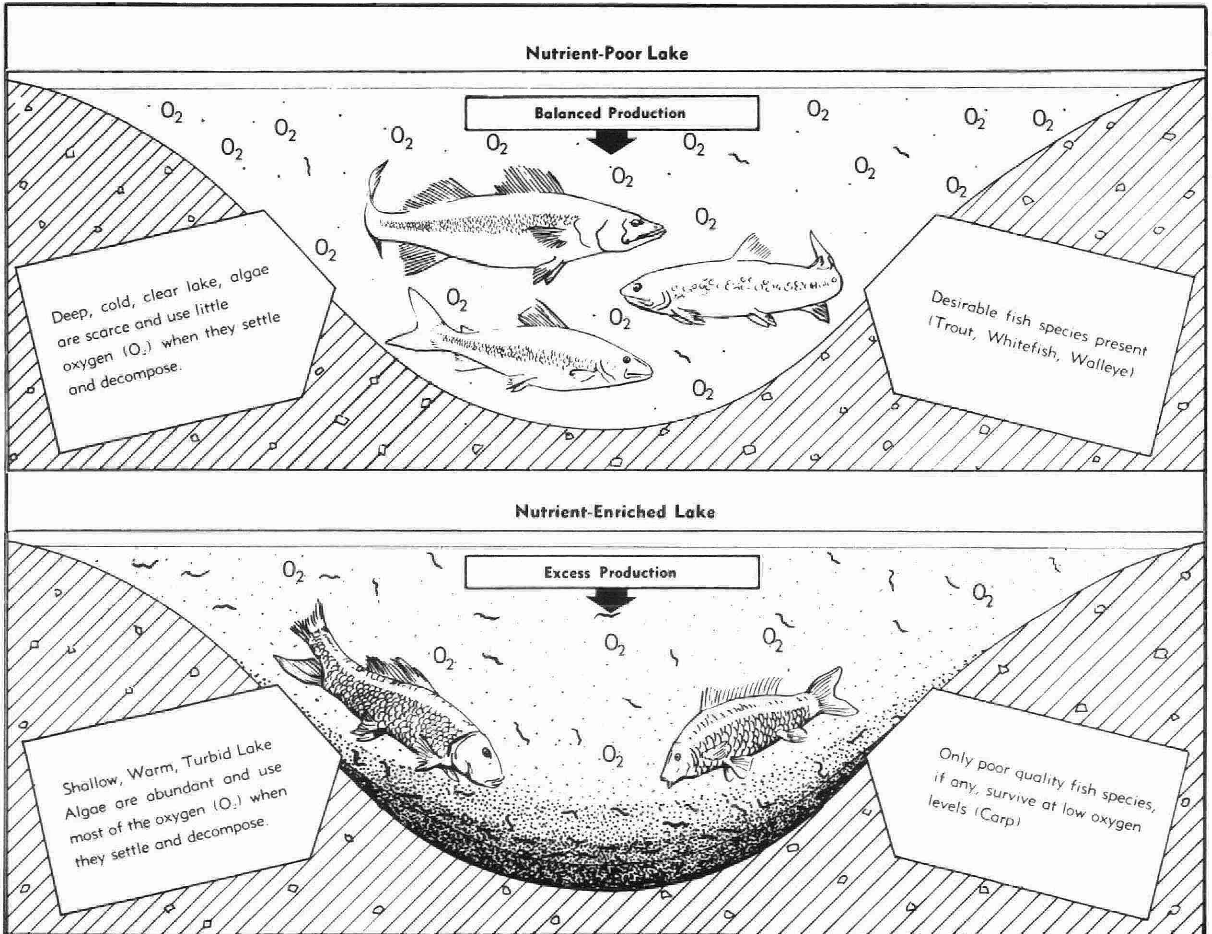
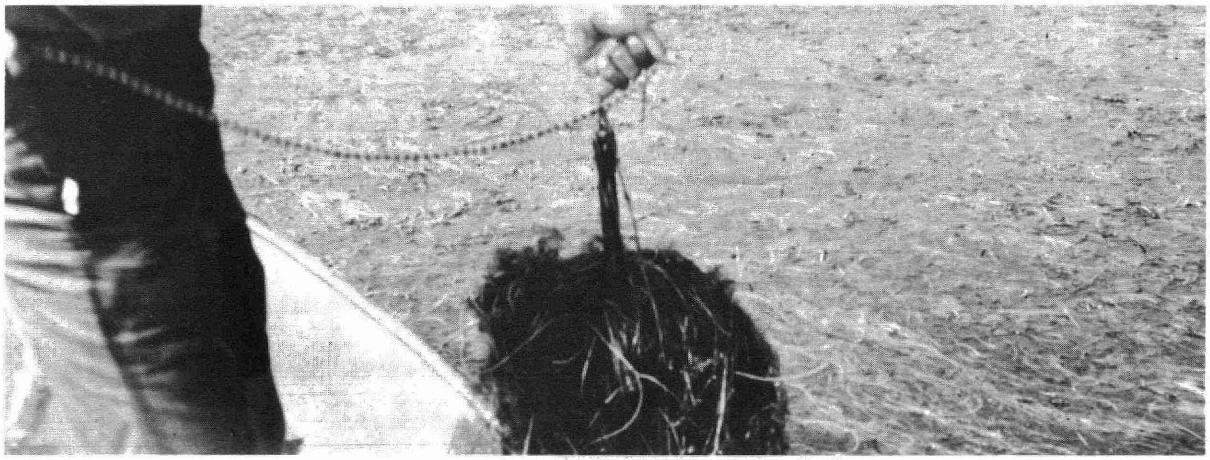

Nutrient-Poor Lake
Balanced Production
Deep, cold, clear lake, algae are scarce and use little oxygen (O_2) when they settle and decompose.
Desirable fish species present (Trout, Whitefish, Walleye)
Nutrient-Enriched Lake
Excess Production
Shallow, Warm, Turbid Lake Algae are abundant and use most of the oxygen (O_2) when they settle and decompose.
Only poor quality fish species, if any, survive at low oxygen levels (Carp)

Figure 1

are increased by farmers who apply artificial fertilizers to their fields. It is important to realize that loss of nutrients from a lake through outflowing streams is relatively small. The nutrients are therefore recycled and become available in increasing amounts for future development of algae and aquatic plant life.

However, a highly productive lake may be a decided asset, depending upon the point of view of the user. For example, the excellent fishing in the Kawartha Lakes is related to the fertility of the water. The abundance of game fish, such as muskellunge, walleye and bass, relates to the availability of small fish as a food source, which in turn are dependent on aquatic insects, water fleas and other invertebrates, all of which owe their existence to the algae. Thus, plentiful algae and plentiful fish appear to be two sides of the same coin in the Kawarthas.

In the past, public enquiries related to the pollutional status of a number of lakes suffering from over-enrichment have led to investigations by Biology Branch staff. Biological parameters measured during these assessments pertain to quantitative and qualitative changes in algal communities and bottom-dwelling organisms. Such changes are related to physical-chemical factors, including morphology of the lake basin, dissolved oxygen in the lower water, transparency, dissolved solids, nutrient determinations and sediment core analyses. Unfortunately, these investigations, as well as most studies carried out elsewhere in the world, have evaluated the problem 'after the fact'. Remedial measures are often too late or too expensive for complete reclamation. It is important to realize that what may limit growth in one lake may not be limiting in other lakes. With these facts in mind, a new technique called the 'Algal Growth Potential' test is being evaluated which will determine the nature and levels of limiting growth factors in any specific lake. Once this knowledge is gained, a logical approach can be undertaken in lake management in terms of its maximum multi-purpose potential.



Algae and weeds may spoil swimming and boating areas

Biological evaluation of water quality

Since 1964, biological surveys have formed an important part of the pollution abatement and water resources management program of the OWRC. Pollution evaluation had previously been accomplished using only chemical and bacteriological parameters. The addition of biological information has afforded a useful tool in determining long-term effects and has placed the overall interpretation of water quality on a more meaningful basis.

In natural waters, one is impressed with the seemingly endless variety of free-floating microscopic plants and animals, bottom-dwelling invertebrates, fish and other aquatic life. Each species forms an integral part of a complex, dynamic 'web of life' which is maintained in a delicate balance through the interactions of various physical, chemical and biological environmental factors. Pollution, through alterations in the natural environment, disrupts the natural balance by allowing only the more tolerant species to exist. The degree of imbalance varies directly as the degree of change in water quality.

Thus, the major interpretative value of biological surveys lies in the collection and identification of various forms of aquatic life, supplemented by chemical and physical measurements in the river or lake being examined. Bottom fauna have several inherent qualities which are advantageous in pollution investigations. These include limited movement, an extended life cycle and the existence of pollution-sensitive, facultative (intermediate) and pollution-tolerant forms. Therefore, the bottom fauna reflect water quality over an extended period of time. Fish populations are often sampled where game or commercial fish production is of importance, and close liaison has developed with the Fish and Wildlife Branch of the Department of Lands and Forests to ensure that due consideration is given to fish management requirements as they relate to water quality maintenance.

There is a wide variation in the effects of pollution on aquatic life, depending on the nature and strength of the offending substance or substances. The adverse effect of acutely toxic pollutants (e.g., heavy metals, synthetic chemicals) upon the aquatic biota is illustrated in Figure 2. There is a sudden elimination of sensitive species until dilution reduces the concentration to a non-toxic level. Where the toxic effects are acute, the toxicity is determined through bioassays (see Toxicity and Bioassay Section and the dilution required to render the waste non-toxic to test organisms is derived. However, more subtle changes may occur. A specific facet of the food web may be more susceptible to the toxicant and its obliteration may be manifested in changes in other segments of the population, e.g., a change in the species composition of fish populations, and a decrease in growth rate may be caused by the elimination of desirable fish food organisms. Some toxic compounds, such as chlorinated hydrocarbon pesticides may be sublethal in their effect. Through the gradual accumulation of pesticide residues in body tissues, death may occur over time, or breeding success may decrease through high concentrations in eggs. Other waste materials (pulp and paper wastes, oils, phenols) cause the tainting of fish flesh and subtle histological and physiological damage.

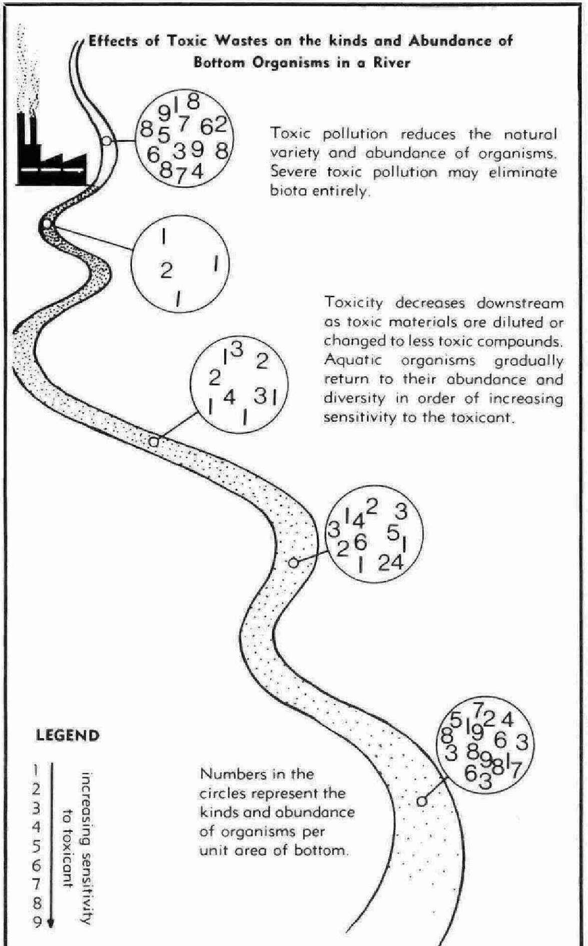


Figure 2

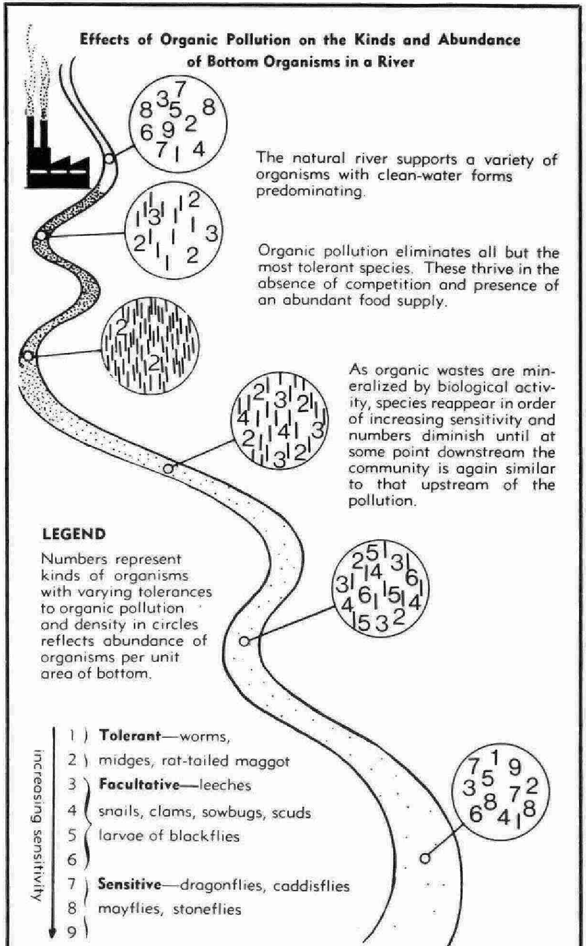


Figure 3

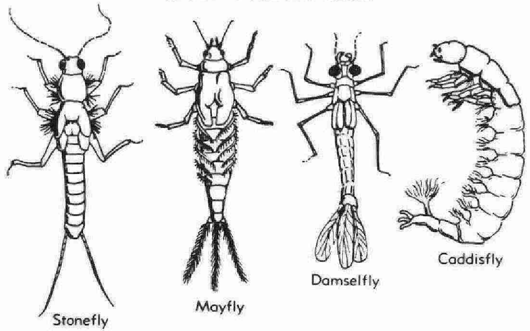
Organic wastes, such as domestic sewage and wastes from food processing plants, slaughterhouses and pulp and paper mills, undergo bacterial decomposition in the water, utilizing significant amounts of dissolved oxygen. The resulting biological community is illustrated in Figure 3. As oxygen levels decrease, organisms die in order of increasing tolerance until only large numbers of a few tolerant species of aquatic worms and midges flourish in the absence of competition and in the presence of such an abundant food source. Excessive organic loads may totally deplete the dissolved oxygen levels and result in the production of toxic gases such as hydrogen sulphide and methane. Under these conditions, even worm populations may be drastically reduced. Fish suffocate owing to the low levels of dissolved oxygen and spawning grounds are ruined by the blanketing of the bottom by solids. Figure 4 illustrates some typical bottom organisms and their natural environmental adaptations which suit them either to clean water or to varying degrees of organic pollution. In evaluating water quality, the biologist must consider the total aquatic community (types and numbers) and the possible relationships between community structure and natural factors such as stream velocity, bottom type and population cycles.

Heated discharges from thermal generating stations may affect aquatic life, although all the facts are not yet known. Concern is held for such possible effects as disruption of fish movements and spawning success, increased production of undesirable filamentous algae and elimination or alteration of bottom fauna and phytoplankton populations.

Soil erosion is another damaging process which has contributed greatly to upsetting the natural production of aquatic life in our streams and rivers. Elimination of trees and other natural vegetation along watercourses and failure on the part of agriculturists to implement sound soil conservation practices has led to the deposition of silt in river systems which smothers bottom organisms, destroys fish spawning areas and accumulates in reservoirs and impoundments so that these become shallow, warm and eventually weedy and unsightly.

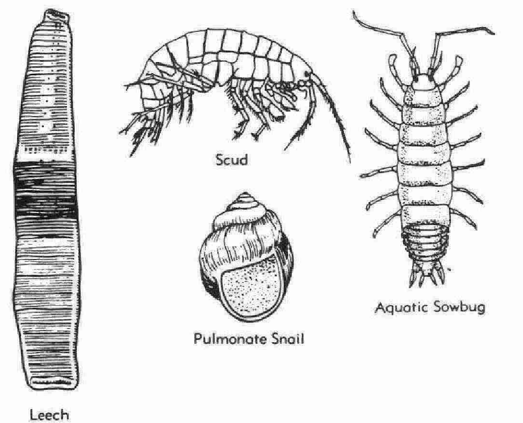
It must be emphasized that seldom do these pollutants occur independently to cause the rather simplified aforementioned disruption of the aquatic community. Interactions between the various pollutants are common and they can combine to nullify the effect of each other or to additively worsen the effect.

CLEAN WATER FORMS

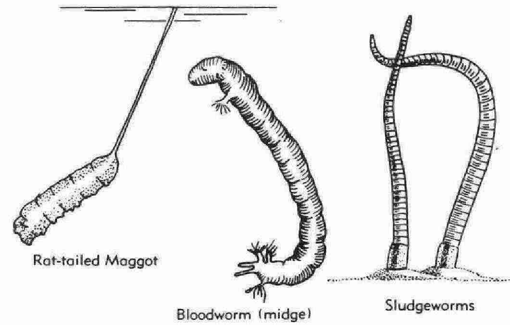


FACULTATIVE FORMS

Diagrammatic representation of typical bottom - dwelling organisms with varying tolerances to organic pollution.



POLLUTION - TOLERANT FORMS



Footnote: Environmental Adaptations

1. Clean Water Forms — These insects have flat bodies with strongly developed legs for clinging to a clean stoney bottom or aquatic vegetation. Respiration is accomplished by exposed delicate gills which are sensitive to abrasion from suspended solids.
2. Faculative Forms — The gills of scuds and sowbugs are protected by chitinized covering plates. Certain snails obtain oxygen from the air which they collect at the surface and carry in their shell. Thus, they escape low levels of dissolved oxygen.
3. Tolerant Forms — The rat-tailed maggot obtains atmospheric oxygen through a telescoping tail which reaches to the surface. Midges and sludgeworms contain the red pigment haemoglobin which enables efficient utilization of very low concentrations of dissolved oxygen.

Figure 4

Pollution evaluation surveys

Surveys are performed to determine the effects that municipal or industrial wastes are having upon a watershed. Often, public pressure or other governmental departments create a demand for information which the biological survey can provide.

Biological surveys are usually carried out in the period between spring and fall. They involve the participation of a supervising biologist and a field technician, usually assisted by two university students. Bottom fauna, algae and fish samples are returned to the central or regional OWRC laboratories for identification and/or analysis, most of which is accomplished during the winter months. Following the completion of each survey, reports are written, describing water quality in the study area, which include recommendations for any pollution abatement programs required to meet the Commission's objectives. These reports are distributed to municipalities, health units, government agencies and any other groups or persons having a direct interest or concern with the water quality in the study area.

A particular survey may be one of several types, depending on the underlying purpose of the investigation. The 'spot survey', by virtue of the rapidity with which it may be completed, is one of the most valuable. It is especially useful in pre- and post-operative studies of new industrial or other waste sources. Conclusions regarding the effect of a particular problem upon a local area may be drawn and a report written within a month of the actual survey. Thus, the benefits of a spot survey are immediate and specific.

A dredge used to sample bottom life in lakes

A Surber sampler is used to sample bottom life in rivers and streams

To assess the overall condition of selected lakes, bays or rivers, the 'watershed survey' is conducted. These surveys reveal the importance of a specific pollution situation relative to others on the watershed and provide adequate baseline data to evaluate subsequent changes in water quality. Conclusions are based on the total allotment of uses (domestic and industrial water supply, recreational, natural transport and purification of wastes) so that one water use does not jeopardize another. Biological data are combined with the results of engineering surveys to predict the effects of waste discharges on a stream and to determine acceptable waste loadings.

After the accumulation of baseline data through the intensive watershed survey, a 'surveillance survey' may be performed at regular intervals. By means of this survey, involving only a few key stations, long-term trends in water quality will be reflected through changes in biological communities.

Toxicity and pesticide studies

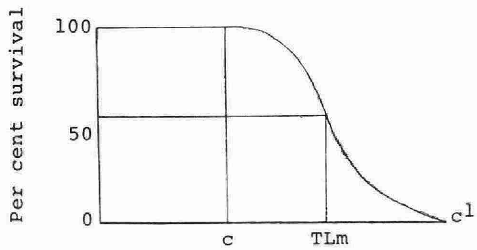
An important phase of the Commission's program in aquatic biology includes acute toxicity bioassays, fish kill investigations, fish tainting studies and monitoring of pesticides in the aquatic environment.

The underlying philosophy of the toxicity and bioassay test is that it should provide a concrete measure of the toxicity of any substance discharged to the waters of the province. The term "bioassay" means, literally, a test of life. The acute toxicity bioassay, therefore, determines what concentration of a substance will be acutely toxic to a particular organism under specified and controlled conditions. Substances commonly evaluated in the bioassay test are industrial wastes, pesticides and water samples associated with fish kills. The unit of measurement of the bioassay is the TLm^t or the medium tolerance limit in a specified time, "t". In setting up a toxicity bioassay, five different dilutions will be prepared and ten fish, usually fathead minnows *(Pimephales promelas)*, will be put into each dilution. Fish are normally used, but other organisms may be tested. Each test has a control group of ten animals. Throughout the test, dissolved oxygen, temperature and pH (the degree of acidity or alkalinity) are monitored continuously. At the end of the test period (usually four days), all the survivors are counted and their numbers are plotted against concentration (Figure 5). From the graph, it can be seen that 'c' represents the concentration at which there is 100 per cent survival and 'c^1' represents the

A fish bioassay test

concentration at which there is zero per cent survival. Halfway between these two extremes will be found the TLm concentration at which there is 50% survival.

No attempt is made to evaluate either 'c' or 'cl', as these values are highly variable due to unusually resistant or susceptible individuals. The concentration range from 0 to c represents the sublethal concentrations in which the subacute effects are manifested. These sublethal effects may be reduced reproductive success, increased susceptibility to disease, or loss of efficiency and vigour in hunting food and avoiding predators. As far as the animal populations are concerned, these sublethal effects can be just as devastating as the acutely toxic effects.



Increasing concentration of toxicant

Once the acute toxicity has been evaluated, the concentration that will kill half the fish population has been defined. Clearly then, this is much too strong a solution to be safely discharged, so that an application or safety factor must be calculated, usually 1:10 or 1:100 of the TLM^{48} or TLm^{96} concentration. The safety factor applied is governed by the stability of the toxicant in the environment and the degree of variability in stream flow. The application factor is based on an acute toxicity determination. There may, however, be other more subtle changes that can take years to manifest themselves which are just as devastating to the fish as if it had been killed directly. An example of this type of sublethal poisoning is the accumulation of the insecticide DDT and its metabolites in the tissues of lake trout. Over a period of years, the fish accumulates the insecticide from minute concentrations in the water and food. When the fish is five to seven years old and beginning to spawn, the female may pass on in her eggs enough DDT to kill the newly hatched fry. If the species cannot produce viable progeny, it is just as serious as if its adult members had been killed outright. It is only after extended periods of investigation that sublethal effects become apparent.

Since pesticides, certain heavy metals and some stable chemicals will accumulate in fish, province-wide efforts have been initiated to determine concentrations of such substances in fish. The species that are being examined include northern pike, an internationally recognized reference species, and species of local sport or commercial value such as yellow walleye, rainbow trout, lake trout and whitefish.

Fish Flavour

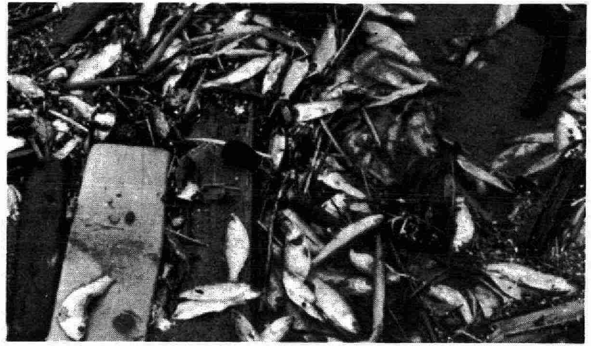
When a substance is discharged into a receiving water, the local fish population will occasionally pick up minute quantities of these substances. If the substance has an unusually strong odour and is very stable, the fish can accumulate enough of the compound to taint their flesh. Frequently, the problem of the tainting of fish is associated with the effluent from a Kraft (sulphate) process pulp mill. These effluents produce an oily, gasoline-like taste in the fish. When a fish tainting problem is suspected, specimens of the local population will be collected along with fish of the same species from several control areas. The fish are cleaned, frozen and shipped to the laboratory for a flavour evaluation. In the lab, portions of flesh are cut from each of the control and suspect specimens. These samples are put in coded dishes, after which they are cooked and tasted by a panel of six people who rate the samples for quality of flavour.

The results of these tests are useful in determining the degree of impact of a particular industry on commercial and sport fishing.

Fish Kills

Another activity is the investigation and compilation of fish kills reported throughout the province. A fish kill is one result of degraded water quality. This degradation may come from the introduction of industrial wastes (pulp and paper mills, tanneries, metal plating plants), sewage treatment plants, agricultural discharges (liquid wastes from piggeries), temporary activities (mosquito control programs, stream dredging projects) or natural causes (winter fish kill, abrupt temperature/dissolved oxygen change or an outbreak of endemic or epidemic

Fish flavour evaluation test



diseases). In the investigation of a fish kill, extensive water sampling is necessary to locate the toxic water and define its limits. The water samples are submitted for chemical and biological analysis. With the aid of the Divisions of Industrial Wastes and Sanitary Engineering, an analytical program is formulated to detect and eliminate the contaminants most likely to have caused the fish kill. In addition to the chemical analyses, the samples are bioassayed to determine the toxicity of the water.

In the field, all possible sources of contamination are examined. The extent and pattern of the fish mortality aid greatly in locating the source of contamination. Thus, if a stream branches, the dead fish can be traced along one of the branches until mortality ceases, at which point a suspect ditch or effluent pipe may be located. If so, obvious sources of contamination are located. The fish kill may be the result of some intermittent activity such as a mosquito control program. If such is the case, the toxic water will be moving downstream as a 'slug', killing most organisms in its path, until it is sufficiently diluted by tributary streams. Sampling should be carried out sufficiently far downstearm to pick up any toxic substances. When the source of the fish kill is located, remedial action is taken to prevent its recurrence.

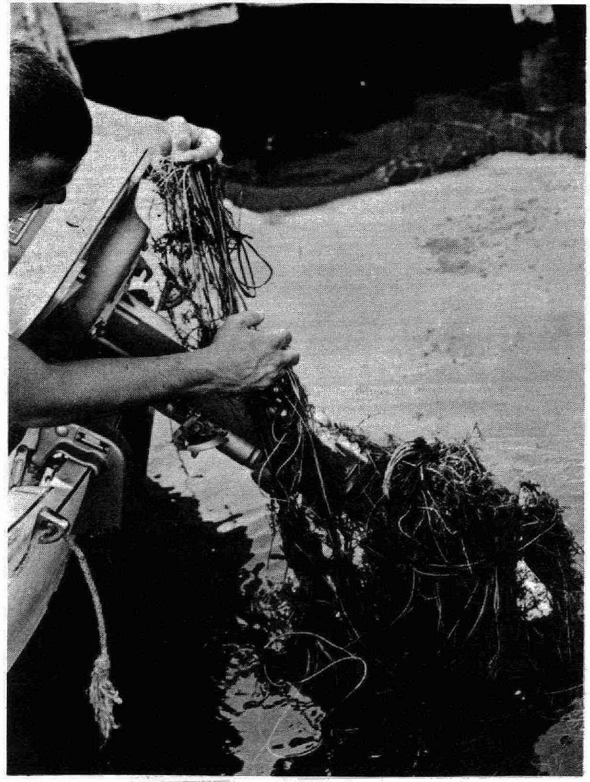
Aquatic nuisance control

The increased pressures on our water supplies have necessitated the manipulation of our aquatic resources to satisfy the multifaceted interests of our society. In view of its major uses, a body of water can be managed with the aid of mechanical or chemical control. Generally, these control measures are confined to nuisance areas and should not seriously disrupt the ecology of the resource.

As has been noted previously, higher aquatic plants and algae have a definite role in the maintenance of a balanced aquatic environment. In addition to maintaining essential oxygen levels through photosynthesis, they provide a suitable environment for the production of fish food organisms and serve as food and shelter for young game fish, forage fish and waterfowl. However, depending on the water uses, there may be situations where their presence is undesirable. An over-production of aquatic vegetation may create unsightly conditions in lakes and ponds and impair recreational uses such as fishing, swimming or boating. Large decaying masses of vegetation can not only render the water less palatable for humans or livestock, but may also cause winter fish kills through the depletion of the dissolved oxygen.

Aquatic Plant Control

Although the control of undesirable aquatic plants may be achieved through either mechanical or chemical means, the use of algicides and herbicides has generally proven to be both more economical and more practical, considering the ease with which they can be applied. A



satisfactory herbicide or algicide must effectively kill the nuisance plants without affecting non-target organisms such as fish, or otherwise impairing the water quality, and should be reasonable in cost.

To acquire adequate knowledge of the control of aquatic plants and algae, the Commission continually undertakes the evaluation of new chemicals. Prior to initiating field work with an aquatic pesticide, standard bioassay tests are performed in the laboratory to determine the median tolerance limits for native species of fish. In the field, the effectiveness of the chemicals in controlling various species of aquatic plants is established, and the effects on bottom fauna and phytoplankton are examined. When necessary, special studies are carried out to obtain additional information. These have included evaluations of the potential effect of herbicides on bass spawning, palatability tests to determine whether 2,4-D-type herbicides would cause fish tainting and determinations of the concentrations at which tastes and odours would be imparted to water, the latter an important consideration where lakes are used for public water supplies.

A waterfront fouled by aquatic vegetation . . . . .

Technical journals, data submitted by companies to secure registration for herbicides and other pertinent information are constantly under review as a part of a fact-finding and interpretative effort.

Since 1962, the Commission has been represented on the Ontario Herbicide Committee. This Committee is responsible for an annual review of recommendations relating to the use of all herbicides in the province. The Commission's representative presents to the Committee new information on aquatic herbicides each year which, following approval, is incorporated into 'Guide to Chemical Weed Control', a publication of the Ontario Department of Agriculture and Food. Some 60,000 copies of this publication are distributed annually.

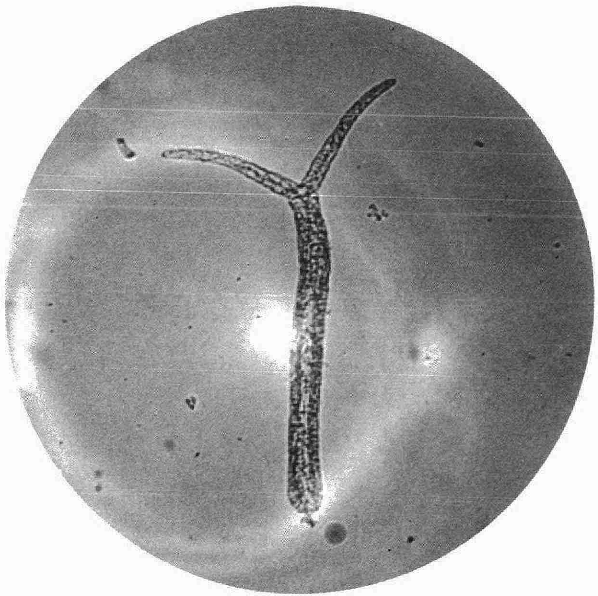
More detailed information concerning the use of aquatic herbicides is provided in an OWRC booklet entitled 'Aquatic Plant and Algae Control'. This booklet includes information on the calculation of dosage rates, application methods and illustrations of the more common aquatic plants native to Ontario. Copies are available from the Biology Branch, Ontario Water Resources Commission, Box 213, Rexdale, Ontario.

. . . . The same area after treatment with an aquatic herbicide

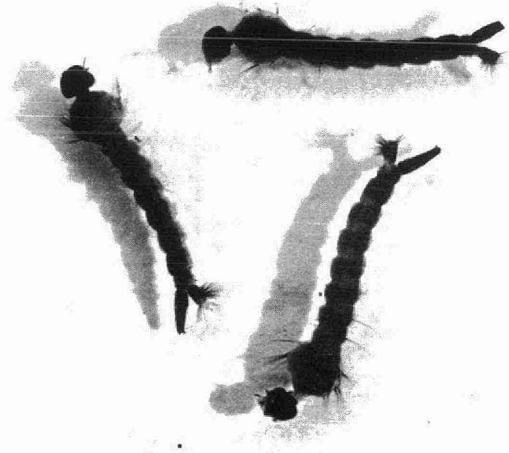
Other Aquatic Nuisances

Certain aquatic animals are considered as pests or nuisances to man through their habits or their role as intermediate hosts for parasites. The two most common nuisances in Ontario are the blood-sucking leeches and the various species of snails that serve as intermediate hosts for certain trematode worms whose larvae (schistosome cercariae) penetrate the skin of bathers, resulting in swimmers' itch. Copper sulphate has been used both for leech control and swimmers' itch control for many years. In the latter case, it reduces the number of snails, which are the intermediate hosts for the tiny parasites. However, copper sulphate is only partially effective for these purposes and is injurious to small fish and aquatic invertebrates on the beaches where it is used. Thus, Commission biologists have been experimenting with newer compounds which will be more effective and less hazardous to non-target organisms.

Biting flies, such as mosquitoes and blackflies, can often interfere with outdoor workmen or prevent the enjoyment of recreational facilities, leading to significant financial losses. Both of these insects spend their early



Parasite responsible for swimmers' itch



Mosquito larvae

development stages in water. Some measure of relief from these nuisances can be achieved through chemical controls during their larval stages.

In the past, DDT has been the most commonly employed insecticide for larviciding programs. However, due to its persistence in the environment and its adverse effects on fish and fish-food organisms, its use is no longer permitted in Ontario waterways. To find a suitable substitute for DDT, the Commission has evaluated several organophosphorus insecticides. These compounds degrade rapidly in the water and current assessments are designed to determine hazards to fish and fish-food organisms at the recommended treatment rates.

Informative pamphlets on the control of mosquito and black-fly larvae, leeches, and swimers' itch are available from the Commission on request.

The Permit System

To ensure the use of acceptable nuisance control chemicals and to forestall any infringements on the rights of other water users, the OWRC Act was amended in 1962 to establish a permit system for regulating the use of nuisance control agents in public waters. Permits, therefore, must be obtained by all persons applying substances to water for controlling nuisance plants or animals, except for two exempted situations. These exemptions apply to treatments in private ponds having no outflow and to treatments of emergent plants in drainage ditches, provided a herbicide is used which is registered for this purpose under the Federal Pest Control Products Act.

Blackfly larvae

The glossary of terms and references following is provided for persons who are interested in more detailed aspects of aquatic biology.

Glossary of terms

Algae—An assemblage of simple, mostly microscopic, non-vascular plants containing chlorophyll. Some algae may produce nuisance conditions when environmental conditions are suitable for prolific growth.

Algal Growth Potential Test—A carefully controlled laboratory test in which equal numbers of algae are added to lake water. The resulting algae growths are compared to a standard "nutrient-enriched" algae culture. Algae growths in the lake water flasks which are similar to the standard indicate excessive fertility or enrichment.

Algicide—Any substance which is used to kill algae.

Autotrophic—Self-nourishing organisms, denoting the green plants and those forms of bacteria that do not require organic carbon or nitrogen but can form their own food out of organic salts and carbon dioxide. Commonly green plants and coloured bacteria.

Bacteria—One-celled micro-organisms.

Bioassay Test—Literally, a test of life. A test in which animals, usually fish, are exposed to various concentrations of a water-borne substance to measure the toxicity of the substance.

Biological Survey—A technique whereby the quality of a lake or stream is measured through evaluation of the bottom-dwelling organisms or other aquatic biota.

Biota (Biotic)—Pertaining to all living organisms in a region.

Bottom Fauna—The total assemblage of animals living on the bottom of a lake, stream or river.

Cercaria—The intermediate stage in the life cycle of a parasitic flat worm. A cercaria resembles a microscopic tadpole with a forked tail.

Chlorinated Hydrocarbon Insecticide—Any of the common insecticides characterized by the presence of chlorine in the molecular structure—e.g. DDT.

Chloroplast—A small, green body containing chlorophyll found in plant cells exposed to light.

Contaminant (Water)—Any undesirable substance or property in water.

Dissolved Oxygen—Oxygen which is dissolved in water and is usually expressed as parts per million.

Diatoms—Microscopic plants which form one group of the microscopic algae. Diatoms are characterized by the presence of silica and markings or striae in their cell walls. The organisms contain a brown pigment in addition to chlorophyll.

DDT—Dichlorodiphenyltrichloroethane

Ecology—The branch of biology that deals with the relationships between organisms and their environments, including their relationships to each other.

Endemic—Regularly found in a specified area.

Epidemic—Prevalent in a community at a specified time.

Eutrophication—The intentional or unintentional enrichment of a lake or stream owing to the presence of essential plant nutrients such as phosphorus and nitrogen.

Facultative—Aquatic organisms that are able to live in both clean and polluted water.

Fish Tainting—Some pollutants have the ability to produce an obnoxious, unpleasant flavour in fish, e.g. outboard motor exhaust.

Food Chain—The dependence of organisms upon others for food. The chain begins with plants or scavenging organisms and ends with the largest carnivores.

Fry—The stage in the life of a fish between the hatching of the egg and the absorption of the yolk sac.

Herbicide—A chemical compound used to kill many types of plants, e.g. 2,4-D.

Histology—The microscopic study of tissues.

Kraft Pulp Mill—A chemical process of producing wood pulp from wood chips using heat, pressure and a strong caustic (alkaline) solution.

Leeches—Segmented worms, flat from top to bottom, with terminal suckers that are used for attachment and locomotion. Various species may be parasites, predators or scavengers; most are aquatic.

Median Tolerance Limit—The concentration of the tested material in a suitable diluent (experimental water) at which 50% of the test animals are able to survive for a specified period of exposure.

Metabolite—Any product of a chemical change, constructive or destructive, occurring in living organisms.

Microscopic—Not visible to the unaided eye.

Midge—Tiny insects, species of chironomids commonly called "blind mosquitoes". The larvae are called bloodworms. Midges sometimes breed in enormous numbers in lakes rich in algae and organic matter (sewage). Important as food for certain species of fish.

Non-target Organisms—In the application of a pesticide a wide variety of desirable organisms may be killed along with the few nuisance or target species.

Organic—Any substance containing carbon.

Organic Pollution—Pollution or contamination of a water body by carbonaceous material, eg. sewage.

Organo-phosphorus—That group of insecticides characterized by the presence of phosphorus in the molecular structure, i.e. Parathion.

Oxidation Pond—A pond for the retention, digestion and decomposition of organic wastes by micro-organisms.

Parasite—An organism that lives on or in a host organism from which it obtains nourishment at the expense of the latter during all or part of its existence.

Periphyton—An assemblage of the aquatic micro-organisms which usually form a slimy coating on the stems and leaves of rooted plants, stones and other objects on the bottom of a water body.

Pesticide—Any substance used to kill pest organisms including the insecticides, herbicides, algicides, fungicides and bactericides.

Photosynthesis—The process by which simple sugars are manufactured from carbon dioxide and water by living plant cells with the aid of chlorophyll in the presence of light.

Phototrophic—Having the ability to respond or responding to light.

Phytoplankton—Free-floating plants of microscopic size.

Plankton—An assemblage of micro-organisms, both plant and animal, that either have relatively little power of self-locomotion or drift in the water subject to the action of waves and currents.

Pollutant—Any substance or character of a water body which inhibits or restricts a legitimate use of that water body.

Predator—Any animal that actively feeds upon other animals.

Progeny—Offspring.

Rat-tailed Maggot—An aquatic fly maggot usually found in foul, often septic water. It possesses a three-segmented, telescopic air tube that extends through the water surface, enabling the maggot to breathe from the atmosphere. The larvae live on decayed organic material.

Schistosome—A parasitic flat worm most commonly found in the small blood vessels of the membranes of the lower intestine of certain mammals or birds.

Sedimentation—The filling in of a lake or reservoir by silt or organic debris carried in by inflowing streams or by decomposing planktonic detritus formed within the water body.

Spot survey—A biological survey of limited time and area carried out to investigate small local pollution problems.

Sublethal—A concentration of a pollutant in the water which may not kill animals directly but which may render them more susceptible to disease, predation or other environmental pressure.

Surveillance survey—A repetitive biological survey designed to monitor water quality conditions over an extended period of time.

Swimmer's Itch—A rash produced on bathers by a parasitic flat worm (i.e. Trematode) in the cercarial stage of its life cycle. The organism is killed by the human body as soon as the skin is penetrated; however, the rash may persist for about two weeks.

Thermal—Pertaining to heat.

Trematode—The common name for a parasitic worm of the class Trematoda, a fluke.

Water Bloom—A readily visible concentrated growth of plankton (plant or animal). A bloom of algae may be so dense that it imparts a greenish, yellowish or brownish colour to the water.

Water flea (Daphnia)—Mostly microscopic swimming animals (microcrustaceans) often forming a major portion of the zooplankton.

Winter kill—The death of fishes resulting from unfavourable dissolved oxygen conditions under ice.

Zooplankton—Animal micro-organisms living unattached in the water. They include small crustacea, such as *Daphnia* and *Cyclops,* and single-celled animals, etc.

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